AC 2012-3044: HOW DOES ANIMATION-BASED LEARNING AFFECT STUDENTS' ACHIEVEMENTS AND ATTITUDES TOWARDS ELECTRONICS?

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How Does Animation-Based Learning Affect Students' Achievements And Attitudes Towards Electronics?

Introduction

One of the fundamental subjects taught in electronics is the bipolar junction transistor (BJT), a topic that requires a firm knowledge of mathematics and physics. Students studying towards a practical engineering degree in electronics often face great difficulty when studying the BJT. The difficulty arises from both the complexity of the device[1] and lack of adequate mathematical and physical background among the students[2] who, after two years in specialized colleges, occupy a position in industry that is intermediate between the engineer and the technician. The authors have therefore recently developed a new learning unit based on computer animation that has been tailored to the practical engineering students' background and qualitatively describes the processes occurring in the transistor. The paper describes the results of a study that compared the academic achievements and attitudes towards electronics of students who learned about the BJT through animation with those of students who learned using static drawings and summarizing notes from the blackboard.

Theoretical Background

<u>Animation-Based Learning</u>

Animation is designed to provide the illusion of movement on the screen. The advantage of animation is particularly evident in cases in which it is hard to demonstrate processes in classroom lessons or even in a laboratory[3]. The cognitive theory of multimedia learning[4] is one of the most comprehensive theories dealing with multimedia based learning in general and instructional animations in particular. The theory assumes the following:

- Dual channel **-** Information is processed through two separate channels: a channel processing auditory – verbal information, and a channel processing visual – pictorial information[5];
- Limited capacity **-** Information processing capabilities in each of the two channels is limited[6] ;
- Active processing **-** The learning process involves substantial cognitive processing in each of these channels. The processing includes paying close attention to the material taught, its organization into a coherent structure and integration into the existing knowledge[7].

There is an ongoing debate in literature over whether the use of computer animation is preferable to traditional teaching methods[8]. It should be noted that studies have not thus far produced any conclusive and consistent results clearly indicating the advantages of one approach over another[8]. However, it appears that animation indeed has many advantages, provided it is properly integrated into the teaching process[9].

Animations dealing with electronic devices at university level have been developed with the expectation that they will help students in understanding the processes occurring in semiconductors[10]. For instance, Lundgren and Jonsson[11] developed animations, for students of electrical engineering focusing on the processes of drift and diffusion in semiconductors, and found a remarkable improvement in the interest shown by students, but not in their level of understanding. It is important, however, to stress that the research population of the above mentioned study comprises students studying towards a first degree in engineering. This population differs substantially from practical engineering students who lack, as stated above, adequate mathematical and physical background[2].

Motivation and Self-Determination Theory

Motivation describes motives for behavior. Theories of motivation attempt to trace the source of motivation and explain processes that drive the individual to behave as he does. Self-Determination Theory[12-13] argues that a person has three innate needs:

- Need for autonomy – The need to feel that the individual's behavior was not forced upon him;
- Need for competence – The need to feel that the individual is capable to meet challenging goals;
- Need for relatedness – The need to be accepted and valued by others.

Conditions supporting these needs foster high quality motivation, i.e., intrinsic motivation arising from interest and enjoyment. Since this theory in the educational context[14] has recently become a leading theory in educational motivation, it will be used to examine the attitudes of students towards electronics.

The Learning Unit

As argued before, students studying towards a practical engineering degree in electronics often face great difficulty when studying the BJT. The difficulty arises from both the complexity of the device[1] and lack of adequate mathematical and physical background among the students[2]. The authors have therefore recently developed a new learning unit based on computer animation that has been tailored to the practical engineering students' background. It should be noted that the decision to develop new animation was made following a thorough search of databases and consulting with senior faculty members in departments of electrical and electronics engineering, after which we concluded that animations on the subject of the BJT currently available are not suitable for practical engineers because they are either too simplistic, or alternatively, because they are at a university level, which requires advanced mathematical and physical knowledge that is not in possession of the practical engineering student.

The purposed unit is based on the Sedra and Smith textbook[15] and qualitatively describes the processes occurring in the transistor in its three modes of operation: cut-off, forward-active, and saturation. The animation was developed using Microsoft PowerPoint. It is not an interactive animation and was presented to the class by the teacher, who could control the pace at which the animation proceeds. Since animation can cause misconceptions among learners[16] the teacher is to accompany the animation with verbal explanations (which are not recorded) in order clarifies its limitations to the students. In the current animation the teacher is to note in his explanations that the animation is not to scale. He must also emphasize that the movement of electrons is accompanied by many more collisions than depicted in animation. In light of animation design principles[17], we took care to incorporate written text in spatial proximity to the animation, and avoided the use of excess items distracting the learner from the point. The screenshot in Fig. 1 describes a BJT in its forward-active mode.

In addition, we developed a parallel learning unit engaged in the same contents as the learning unit described above, only it does not include computer animation but uses static diagrams drawn on the blackboard. The research compares the academic achievements and attitudes of students who studied the different units.

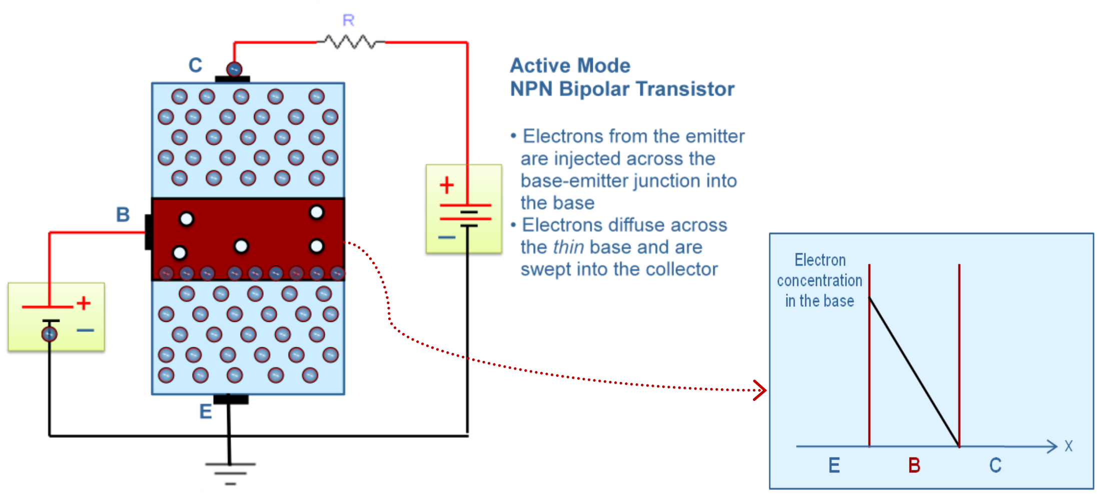

Fig. 1: Screenshot describing the processes electrons (marked as blue balls) undergo in the transistor in forward-active mode. The holes are marked as hollow balls.

Methodology

The research population comprised 41 students who in 2011 were studying towards a practical engineering degree in electronics at a leading college in Israel. The students were randomly assigned into two groups:

- An experimental group of 21 students – where the structure and principle of operation of the BJT is learned through animation presented by the teacher;
- A control group of 20 students – where students studied these subjects using static diagrams drawn on the blackboard by the teacher.

Members of each group were examined in an identical preliminary achievement test on the subject of the diode, which is a prerequisite subject to BJT. It should be noted that the subject of the diode was taught using static drawings. Later, the experimental group learned the structure and principle of operation of the BJT through animation presented by the teacher, while the control group learned the same contents, for the same number of hours and by the same teacher, using static diagrams drawn on the blackboard. At the end of learning, the two groups were examined in an identical final achievement test on the subject of the BJT. In addition, members of each group completed a Likert-like attitude questionnaire before studying the subject of the transistor and after it.

Each of the two achievement tests, the preliminary and final ones, was validated by two experts from the field of education in electrical and electronics engineering. To ensure objectivity, each test was graded by two independent reviewers, using a rubric. The tests, which did not include the name of the examinee but rather only his identification number, were graded in random order to mix the experimental group members and the control group members.

Each of the two attitude questionnaires, the preliminary and final ones, was validated by two experts from the field of education in electrical and electronics engineering. The preliminary attitude questionnaire**,** completed prior to learning the subject of the transistor, included 10 statements dealing with enjoyment and interest associated with learning electronics and the existence of a sense of competence to successfully deal with problems on the subject of the diode. The internal consistency of the questionnaire was measured using Cronbach's alpha coefficient. This coefficient was found to be 0.77, indicating an adequate level of internal consistency. The final attitude questionnaire**,** completed after learning the subject of the transistor, included 10 statements dealing with enjoyment and interest associated with learning electronics and the existence of a sense of competence to successfully deal with problems on the subject of the transistor. Cronbach’s alpha was found equal to 0.83, indicating a good level of internal consistency.

Findings

Table 1 shows the total score (out of 100 points) on the achievement tests (mean M and standard deviation SD) obtained in each group, and the corresponding P-values obtained from performing t tests. Before learning the subject of the transistor there was no significant difference between the experimental group and the control group, but afterwards – the mean total score of the experimental group (78.24) was significantly higher than that of the control group (66.15).

Group	N	Pretest				Posttest			
		M	SD	t	P-value	M	SD	t	P-value
Experimental	21	67.95	23.54	0.31	n.s.	78.24	11.13	3.37	<0.001
Control	20	65.80	20.30			66.15	11.86		

Table 1: Total score (mean and standard deviation) and P-values obtained on achievement tests

Table 2 shows the index median (m) on the attitude questionnaires and the corresponding P-values obtained from performing the Mann-Whitney test (a normal distribution of the index cannot be assumed; therefore we performed a non-parametric test). Index values range between 20 and 100 points. Before learning the subject of the transistor there was no significant difference between the experimental group and the control group, but afterwards the median of the experimental group (82) was higher than that of the control group (62) and there is a significant difference between them. These results indicate that the experimental group students' attitudes towards electronics are significantly more positive than their counterparts in the control group. Students who learned about the BJT through animation found electronics to be more interesting and had stronger feelings of competence than did their peers from the control group.

Group	N	Pretest		Posttest	
		m	P-value	m	P-value
Experimental	21	71	n.s.	82	<0.01
Control	20	67		62	

Table 2: Index median and P-values obtained in attitude questionnaires

Discussion

The research results indicate a significant gap of more than 12 points on average between the academic achievements of students studying the subject of the transistor through animation and the achievements of their colleagues who studied it using static diagrams. The research also shows that students who studied about the transistor through animation express significantly more positive attitudes towards electronics than their peers. The gap is expressed by a difference of 20 points in the index median in favor of the experimental group members. Thus, students studying on the subject of the transistor through animation feel more interest and enjoyment in electronics classes than their peers who studied using static diagrams. Moreover, their sense of competence to successfully deal with problems in the field is higher compared to their colleagues. These findings can be explained by the self-determination theory[12-14] discussed above, and according to which, improved understanding contributes to satisfying the need for competence and thus enhances the intrinsic motivation, whose most prominent characteristic is the display of interest.

These results are consistent with the recent findings of Sihar et al.[18] who developed, for students of physics, a courseware on semiconductor devices. They report improved student achievements as well as positive attitudes toward learning. It is important, however, to stress that the research population of the above mentioned study comprises students studying towards a first degree in exact sciences. This population differs substantially from practical engineering students who lack, as stated above, adequate mathematical and physical background[2].

Despite a relatively small sample size, this study enjoys significant strengths: the students participating in the study were randomly assigned into experimental and control groups and the two groups learned the same contents for an identical number of hours with the same teacher, who took care that the only difference between the two groups will be around the method of instruction (i.e. animation or, alternatively, static diagrams).

We recommend that our colleagues include animations, developed with an eye toward the students' background, when teaching the operation principles of electronic devices such as the BJT.

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